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an accurate mapping of the surrounding neighbourhood, at the same time supplying full particulars.*

A discussion having taken place relating to the locality of the ancient remains described by Mr. Conwell, it was—

RESOLVED,—That it be recommended to the Council to make an application to Government to have the hitherto undescribed monuments near Oldcastle surveyed, measured, and mapped.

The Rev. SAMUEL HAUGHTON, M. D., Fellow of Trinity College, Dublin, read the following paper :—

NOTES ON ANIMAL MECHANICS.

No. III.—ON THE MUSCULAR MECHANISM OF THE LEG OF THE OSTRICH.

ON the occasion of the death of a fine male Ostrich, during the month of January last, in the Zoological Gardens of this city, I secured the body for dissection in Trinity College, and requested Mr. Macalister, of the Royal College of Surgeons, to avail himself of the opportunity thus afforded of completing the anatomical investigations he had previously commenced in the Royal Dublin Society, by the dissection of a female Ostrich, in the summer of 1863. Mr. Macalister availed himself of the opportunity, and has laid before the Academy such results of his dissections as seemed to him most worthy of record. My own attention was directed especially to the investigation of the muscular mechanism of the leg of the Ostrich, which I have long regarded as one of the most interesting pieces of mechanism in the animal kingdom, and I was fortunate enough to discover, in the digastric *rectus femoris* muscle, what I believe to be the key to the explanation of the complicated muscular apparatus of the Ostrich's leg.

The leg of the Ostrich is to be regarded as a long rod bent at four distinct points, which attains its greatest amount of shortening or bending at the moment the foot touches the ground, and which is suddenly straightened or elongated by the simultaneous contraction of all the muscles. The effect of the sudden elongation of the leg is, to throw the whole body of the bird forward, as if from a catapult, from the point of support of the foot; and while the body of the animal is thus projected through the air, the antagonist muscles that flex the several joints come into play, and are assisted in their action by some very remarkable contrivances in the heel joint, which I shall describe and figure.

It is necessary to the perfection of the mechanism, that the greatest possible amount of muscular force shall be expended in straightening or unbending the legs, alternately projecting the animal from foot to foot along the ground, the leg being at its maximum of flexure at the moment of touching the ground, and at its maximum of elongation at the moment of leaving it; and also, that the minimum possible amount of force shall be expended in flexing each leg, preparatory to its next spring, which must take place on touching the ground.

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* The references in the above paper are to drawings preserved in the Library of the Royal Irish Academy.—ED.

I shall show that the leg of the Ostrich fulfils these two conditions of perfect mechanism; but, before doing so, I shall describe in detail the muscles employed in the act of running by the Ostrich.

Part I.—Description of the Muscles.

1. A muscle, which must be regarded as a combined *tensor vaginæ femoris*, *glutæus maximus*, and *agitator caudæ*, takes its origin from the whole length of the posterior edge of the ilium (and first two caudal vertebræ) forwards to the commencement of the *symphysis iliaca*, *a*, *a*, *a* (Fig. 6), and is inserted as follows:—

(*α*). The *tensor vaginæ* portion is inserted into a broad tendon, passing over the outer side of the knee; this tendon forming also one of the origins of the *gastrocnemius*.

(*β*). The *glutæal* portion of the muscle is inserted, partly like (*α*), and partly by a muscular slip, into the middle of the *vastus externus*.

(*γ*). The *caudal* portion of this muscle is inserted into the posterior border of the tendon (*α*), near the knee: the weight of the whole muscle is . . . . 46$\frac{3}{4}$ oz.

2. *M. glutæus medius* has the origin marked *b*, *b*, in Fig. 6, on the surface of the ilium, and is inserted in the small pit, on the outside of the head of the femur (Fig. 7), and rather behind; its weight is . . . . 13$\frac{1}{4}$ oz.

Fig. 6.

3. *M. glutæus minimus* in the Ostrich is correctly so named, for it is a very small muscle; it arises from a thin line on the ilium, an inch and three-quarters in length, shown at *c, c*, Fig. 6, just behind the origin of the *iliacus*, and is inserted, with the *opponens quadrato femoris*, below the great trochanter, on the front of the femur (Fig. 7); its weight is . . . . 1 oz.

4. *M. biceps femoris* has a bony origin, below that of the *glutæus maximus* on the ilium, and lies along the entire surface of the bone, between that muscle and the *semimembranosus, h, h* (Fig. 6); it is inserted into the tubercle in the middle of the fibula; its weight is . . . $41\frac{1}{4}$ oz.

5. *M. semitendinosus* takes its origin from the bony prominence of the posterior extremity of the ilium, from the tuber ischii, and the membrane that joins these two points, *j, j* (Fig. 6), and is inserted into the inner margin of the upper and posterior surface of the tibia; its weight is . . . . 14 oz.

A remarkable accessory muscle arises from the insertion of the *adductor magnus* (Fig. 7) in the femur, and is fastened into the tendon of the *semitendinosus*, near its insertion into the tibia. This accessory muscle weighs 1 oz., and runs nearly at right angles to the tendon of the *semitendinosus*. Its action is to lift and guide the tendon, so as to increase the force of the *semitendinosus* in propelling the body forwards when the foot is fixed. The mechanical use of this muscle is similar to that of the *accessorius flexori digitorum longo* in the sole of the human foot.

Fig. 7.

6. *M. semimembranosus* has its origin on the ilium, below the biceps, as shown at *i, i*, Fig. 6; and is inserted in a line commencing at the top of the *linea aspera* of the femur (Figs. 7, 8), and extending to the fascia of the thigh down as far as the inner side of the knee; its weight is . . . . 17 oz.

The similarity of its use to that of the *glutæus* (1) is shown by the circumstance that it sends a slip ($1\frac{1}{2}$ oz.) backwards to the sides of the first two or three caudal vertebræ, which must be regarded as an additional *agitator caudæ*.

7, 8. *M. vastus externus* is composed of two parts—

M. v. e. 1. Having an inverted ┬-shaped origin from the great trochanter, between the insertions of the *glutæus medius* and *minimus* (Fig. 7); it is inserted on the outer side of the capsule of the knee joint; its weight is $25\frac{1}{2}$ oz.

Its action is to the outside of the plane that coincides with the greatest diameter of the highly elliptical cross section of the femur.

M. v. e. 2. Arises from the whole outer surface of the femur (Fig. 7); it has an insertion similar to that of *M. v. e.* 1; its weight is . . . 5 oz.

9, 10. *M. vastus internus*, like the preceding, is composed of two parts, whose origins are shown in Fig. 8—

Fig. 8.

M. v. i. 1. Arises from the upper and inner surface of the femur, and is inserted into the inner side of the head of the tibia, into the inner edge of the patella and of the ligamentum patellæ; its weight is . . . . . . 13½ oz.

M. v. i. 2. Arises from the lower portion of the inner surface of the femur, and is inserted into the tendon of the former (*M. v. i.* 1); its weight is . . . . 3¾ oz.

The resultant plane of these two muscles lies as much to the inside of the plane of maximum strength of the femur, as that of the *vasti externi* lies to the outer side of the same plane.

11. *M. cruræus.*—Its origin, which lies altogether on the inner side of the femur, is shown in Fig. 8; it is inserted without a tendon into the patella; its weight is . . . 7¼ oz.

Its plane of moment coincides very nearly with that of the *vasti interni*, just described; and it is almost impossible to avoid coming to the conclusion, that the peculiar elliptical cross section of the femur, and its longitudinal plane of maximum strength, are contrived with reference to the strain of these muscles, so as to enable the slight and delicate structure of the femur (peculiar to all birds), to resist the action of the forces brought to bear upon it, and which exceed in magnitude those acting on the limbs of most quadrupeds.

12. *M. rectus femoris* is not correctly described in any book that I have seen; and its true nature, and connexion with the muscles of the calf, were discovered by me quite accidentally. I had taken for granted, as a matter of course, that the *rectus femoris* terminated in the patella; but, as there were two patellas, I wished to know in which of them the muscle terminated: on dissection, to my surprise, I found that instead of ending in either patella, its tendon passed in a groove over and between them both, and, turning outwards and backwards into the calf of the leg, became provided with a second muscular belly, which formed one of the portions of the *flexor digitorum magnus*, the conjoined tendon of which passed under the heel, and terminated in the plantar surface of the toe.

The *rectus femoris*, with its tendon, is therefore truly a digastric muscle, upwards of five feet in length (Fig. 9), and has its origin in the anterior bony prominence of the ilium, *e*, (Fig. 6), which is well marked on every pelvis of the Ostrich that I have seen. The tendon of this digastric muscle is united to that of the *gastrocnemido-solæus*, by a slip shown at *a*, Fig. 9.

The weight of the fleshy belly of the *rectus femoris* proper is 7¼ oz.

13. *M. sartorius.*—This important and remarkable muscle arises from the anterior portion of the ilium, *g*, (Fig. 6), and from some of the spines of the lumbar vertebræ; and, passing in the usual manner across the inner aspect of the thigh, is inserted into the inner side of the ligamentum patellæ and into the top of the tibia; its weight is . . 18 oz.

14. *M. iliacus*—Has a lozenge-shaped origin on the anterior portion of the ilium, between the *opponens quadrato femoris* and *glutæus minimus*, *d*, (Fig. 6). Its insertion into the femur is shown in Fig. 8, at a point which must be supposed to represent the lesser trochanter; its weight is . . . . 1¾ oz.

15. *M. gracilis* arises, like the *semitendinosus*, from the tuber ischii, and from the lower half of the ligament joining it to the posterior spine of the ilium; and is inserted into the fascia of the inner side of the knee joint; its weight is . . . . 4½ oz.

16. *M. adductor magnus* arises from the anterior half of the ischial line, *k*, *k* (Fig. 6), and is inserted into the upper margin of the condyloid pit at the back and inner side of the femur (Fig. 7); its weight is . . . . 4¾ oz.

Its fibres were pale and fatty in the specimen dissected by me.

17. *M. pectinæus* arises from the pectinæal point, *l*, (Fig. 6), and is inserted into the tibia on the inner side of the knee, and is intimately connected by muscular fibres with *vastus internus* (2); its weight is 4 oz.

Fig. 9.

DIGASTRIC MUSCLE,

Composed of *rectus femoris* and part of the *flexor digitorum magnus*.

a, Tendinous slip, uniting the tendon of Digastric muscle with that of the Gastrocnemido-solæus.
b, Fleshy line of union with main body of the *Flexor digitorum communis*.

The blending of the fibres of *pectinæus* with those of the *vastus internus*, a portion of which, like this muscle, terminates directly in the tibia, is not to be forgotten in considering the mechanical action of the muscles of the hip and knee joints.

18. *M. quadratus femoris* has an origin on the ischial line, just below that of the *M. adductor magnus*, and an insertion of a linear shape in the back of the upper portion of the femur, shown in Fig. 7; its weight is . . . . 2¾ oz.

19. *M. opponens quadrato femoris.*—This muscle I have so named, because it is met with in many animals as the direct opponent of the

quadratus femoris. In the muscular system of the Ostrich and Lion this antagonism between the muscles is very striking. It is found occasionally in human subjects, and is described by Harrison under the name of *M. ilio-capsularis*. While we had the Ostrich in the Dissecting Room of Trinity College, a human subject was brought in, which had the ilio-capsular muscle fully developed; and my attention was called to it by Dr. Bennett. I have occasionally found the ilio-capsular muscle in dissecting Monkeys.

In the Ostrich, the *M. opponens* has an origin on the anterior surface of the ilium, between those of the *Mm. sartorius, rectus, iliacus,* and *glutæus medius,* as shown at *f*, (Fig. 6); and is inserted in the anterior ridge at the base of the great trochanter, with the *M. glutæus minimus* (Fig. 7), with the fibres of which it is connected; it weighs . . . $1\frac{3}{4}$ oz.

20. *M. obturator.*—In the Ostrich, as in most birds, the internal and external obturator muscles are united, arising from both the inside and outside of the bony circumference of the obturator foramen, and from both sides of the obturator membrane; their common tendon passes through the ischiadic notch, *n*, (Fig. 6), which forms a pulley, changing the direction of the force through 90°, and receives, on emerging from the notch, the fibres of the little *gemelli*, placed at each side, anterior and posterior, to guide the obturator tendon to its insertion (Fig. 7) on the outer part of the top of the femur; it weighs . . . . . $17\frac{1}{2}$ oz.

21, 22.—*Mm. gemelli* weigh . . . . $\frac{1}{4}$ oz.

23.—*M. coraco-clavicularis.*—In the wing of the Ostrich there is a very remarkable muscle, which arises from the bony margin of the coraco-clavicular foramen; this foramen corresponds in the upper extremity with the ischiado-pubic or obturator foramen of the lower extremity; and the muscle, passing under a strap ligament on the shoulder to be inserted in the outer part of the great tuberosity of the humerus, corresponds with the obturator muscle of the leg.

I consider this muscle to be the second pectoral of ordinary birds, and to be the proper *levator humeri*. It is usually placed between the first and third pectorals, on the sternum, and lifts the wing by means of a pulley, which changes its direction through 135°. This contrivance is necessary in birds of flight, in which it is of as much importance to stow the weight aft, as it is in ships to place the foremast well forward; but, as the Ostrich is a running bird, the Divine Contriver has left the second pectoral to lift the humerus by a direct pull, without expending any ingenuity on pulleys to change its direction, as is absolutely necessary in birds of powerful flight such as the Falcon, in which the pulley of the second pectoral is as remarkable a contrivance as the pulley of the obturator muscle in the Ostrich.

In fact, throughout the whole range of the muscular mechanism of various animals, every pulley changing the direction of an original force presents a problem to be solved; and tells us of a contriving mind, which has deviated, for some purpose discoverable by us, from the simple contrivance of muscular fibres pulling directly from their origin to their insertion.

24. *M. gastrocnemido-solæus.*—This great muscle has four distinct heads—

(*a*). From the outer side of the patella and of the ligamentum patellæ.

(*β*). From the external condyle of the femur (Fig. 7.)

(*γ*). From the condyloid pit of the inner condyle, between the *Adductor magnus* and *Flexor digitorum* (Fig. 7).

Fig. 10.

(*δ*). From the tubercle of the tibia at both sides, and from the surface of the lower patella, and by means of fascia, to the upper part of the fibula.

Altogether it weighs . . . 115½ oz.

This enormous mass of muscles represents the *gastrocnemius* and *solæus*, intimately connected in their fleshy portion, but distinct both in origin and insertion. It is inserted, as shown in Fig. 10, by means of two powerful tendons into the upper and back part of the metatarsus, the tendon of the *solæus* being a little above that of the *gastrocnemius.*

It may be regarded as acting from the circumference of a ring placed all round the knee joint, to the tendo Achillis; and its resultant pull is nearly in the axis of the leg.

25. *MM. flexores digitorum.*—These important muscles may, in the Ostrich, be divided into two distinct groups:—

A.—This group arises from a triple origin:—

(*a*). The condyloid pit of the femur, below the origin of the Gastrocnemius (Fig. 7).

(*β*). From the outer side of the outer condyle of the femur (Fig. 7).

(*γ*). A fleshy slip connects these flexors with the belly of the digastric *rectus femoris* in the calf of the leg. This slip is represented, cut off at the point *b*, in Fig. 9.

Their total weight is . . . . 16 oz.

B.—This group has a double origin:—

(*a*). From the condyloid pit of the femur.

(*β*). From the whole back of the fibula and tibia, except that part which is covered by the *poplitæus.*

Their total weight is . . . . $9\frac{3}{4}$ oz.

26. *M. tibialis anticus.*—This is a flexor of the metacarpus, and arises from the two anterior tubercles of the tibia, and from the front of the external condyle of the femur (Fig. 8). It is inserted below the heel joint, by means of a split tendon, into the front of the metatarsal bone, two inches below the joint (Fig. 10). Its weight is . . . . $8\frac{3}{4}$ oz.

27. *M. extensor digitorum communis* (Fig. 10).—This muscle takes a fleshy origin from the tubercles of the tibia, and from the crest in front of the tibia. It is inserted into the toes, and into the annular ligament of the phalangeal joints. It has no action in flexing the metatarsal bone, except perhaps in some unusual positions of the foot. Its weight is . . . . $5\frac{1}{4}$ oz.

28. *M. poplitæus.*—Well marked, and rotates the fibula on the tibia. Weight, ... $\frac{3}{4}$ oz.

PART II.—ACTION OF THE MUSCLES.

In the act of running, the leg of the Ostrich is to be regarded as a jointed lever, having four joints, viz., the hip, the knee, the heel, and the metatarsal joints. As the animal springs from foot to foot, the whole limb on reaching the ground is bent as far as possible at each of the articulations; and when the spring is made, the muscles proper to each joint increase the angle made by the bones meeting at the joint, so that the effect of the whole is to unbend the limb, and give it a maximum of extension at the moment of leaving the ground. During the spring, the antagonist muscles again bend the joints, so that on next touching the ground it is at its maximum of flexion, again waiting to be unbent by the muscles that open the angles of the joint; and so on for ever, as the animal runs, it is thrown alternately from each foot in contact with the ground, as from a catapult, and advances by successive leaps or springs from foot to foot.

To take mathematical account of the moments of the muscular forces round each joint, it would be necessary to make the following measurements:—

Let O and I be the origin and insertion of any muscle, and A the centre of motion of the joint. The effect of the contraction of the muscle is to develope a moment or couple round the point A, acting in the plane OAI, and proportional to the weight of the given muscle, as already shown in Note I. If it be required to find the total effect of the muscles acting on a given joint with respect to any line, AX, we should have to find the angle made by each plane of moment, OAI, with the line AX; and so calculate by the usual rule of composition of moments the total effect of all the forces acting, and tending to produce rotation. Without going into minute detail, and taking only the muscles that act perpendicularly, or nearly so, to the transverse horizontal axis, we find the following muscles to represent the moment of the spring forwards :—

I.—*Muscles extending the Thigh on the Axis of the Body.*

1. Tensor vaginæ femoris,	46·75
2. Glutæus maximus,	
3. Agitator caudæ,	
4. Biceps femoris,	41·25
5. Semimembranosus,	17·00
6. Semitendinosus,	14·00
7. Gracilis,	4·50
8. Adductor magnus,	4 75
9. Pectinæus,	4·00
	132·25

II.—*Muscles extending the Leg on the Thigh.*

10. Rectus femoris,	7·25
11. Vastus externus, (1)	25 25
12. „ „ (2)	5·00
13. Vastus internus, (1)	13·50
14. „ „ (2)	3·75
15. Cruræus,	7·25
	62·00

III.—*Muscles extending the Metatarsus on the Leg.*

16. Gastrocnemido-solæus,	115·50
17. Flexores digitorum (A),	16·00
18. Flexores digitorum (B),	9·75
	141·25

The total combined effect of these muscles projecting the body forwards is therefore approximately represented by 335·50 oz. of Ostrich muscle.*

After the foot of the Ostrich has left the ground, and during his

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* If we knew the weight of the Ostrich, and the length to which it can spring in a single maximum stride, we could easily calculate the work done in a single effort by a given weight of Ostrich muscle. I do not know how far an Ostrich in a state of nature can spring, nor how high, and am therefore unable to make the required calculation; but I give here two corresponding problems for man, which may be interesting to the physiologist.

Problem 1.—A cricket ball, weighing 5½ oz., is thrown a distance of 91 yards; find the work done by the muscles.

The thrower, by practice, finds the angle of maximum range, or 45°; and as

$$R = 2h \sin 2e$$

for the maximum range, h the height due to the velocity of projection is found to be 136·5 ft. This is the height to which 5½ oz. are raised, and therefore the work done is found to be 46·92 lbs. lifted through one foot.

Problem 2.—A young man, weighing 120 lbs., leaps horizontally 20 ft.; what is the work done? By the same method of calculating, we find the work done in this case to be 1200 lbs. lifted through one foot. This large amount of work is not given out in a single spring; for it represents the sum total of the single spring and of the velocity spring through the air, the following muscles are employed in flexing the several joints, so as to have them in readiness for another spring as soon as the foot touches the ground.

I.—*Muscles flexing the Thigh upon the Axis of the Body.*

1. Sartorius,	18·00
2. Iliacus,	1·75

II.—The flexure of the leg upon the thigh seems to be effected by the *vis inertiæ* of the former, when the latter is drawn up towards the body in the spring.

III.—*Muscles flexing the Metatarsus upon the Leg.*

3. Tibialis anticus,	8·75
4. Extensor digitorum communis,	5·25
	14·00

Fig. 11.

From this it would appear that the moments of the muscles flexing the joints of the limb, during the spring, are represented by 33·75 oz.

This is a small amount of force compared with that employed in extension, and in propelling the body forwards; but the flexor muscles are aided by *inertia*, and by a special contrivance in the heel joint, that remains to be described.

The articulating surfaces of the bottom of the tibia and top of the metatarsus, or cannon bone, are so formed, that it is easier to flex the joint forwards than backwards. This is effected by making the anterior curvature more rapid than the posterior curvature, which produces what connoisseurs in horses would call a beautiful "gig action;" and this natural disposition of the joint is further aided by two admirably contrived check ligaments, shown in Figs. 11, 12, which render the motion forwards much easier than that backwards.

In Fig. 11 I have shown the tendons of *M. gastrocnemius* and *M. solæus;* and in Fig. 12, the tendons of the *flexores di-*

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acquired in running up to the point of starting; and the whole art of long jumps resolves itself into jumping vertically with a velocity equal to the acquired horizontal velocity, and making both quantities a maximum.

gitorum communes, passing under and through the tendon of *M. gastrocnemius*.

Fig. 12.

In Fig. 11 are also shown the tendons of *M. tibialis anticus*, and *M. extensor digitorum communis*, passing through a common "dead eye" bolt—a contrivance necessary to keep them in their place on the flexure of the heel joint, and corresponding with the annular ligament of the human foot. In consequence of the arrangements just described, the foot of the Ostrich is jerked forward suddenly, after passing a position of unstable equilibrium, or "dead point," as it is called by mechanical engineers; and is slowly drawn backwards beyond that point by the action of the powerful extensors of the joint, when they are employed in making a spring.

Any observer who examines the gait of the Ostrich, Emu, Cassiowary, or Rhea, in confinement, cannot fail to be struck with the ungainly effect produced on the appearance of the animal, when walking slowly, by the abrupt and odd-looking lifting of the foot caused by the structure of the heel joint, giving an effect like that of string halt in horses; but this unpleasing impression would be rapidly converted into admiration, if he could see the bird in rapid motion over rough ground, springing from foot to foot, and bending the foot as it left the ground with the rapidity of lightning, avoiding skilfully, without an apparent effort, the dangers of the rough soil. I have been informed by eyewitnesses, that under such circumstances the Ostrich in South Africa almost touches the ground alternately on each side with its body, in every successive spring, and leaps with ease over rocks and shrubs of considerable dimensions that lie in its onward path.

I have shown in the preceding part of this paper, that the force expended in propelling the body of the ostrich forward is ten times the force employed in restoring the legs of the animal, preparatory to its next spring; more exactly, as 335·5 to 33·75. This enormous force acts upon bony supports, which are required by the necessities of a bird's existence to be as delicate and light as possible; and it is, moreover, exerted almost instantaneously, so as to give the fullest effect to the bird's spring. The question naturally arises, how is this force to be suddenly applied, without breaking or dislocating the animal's legs?

The answer to this question is to be found in the peculiar structure of the *rectus femoris* muscle, which binds down the patellæ, straps up the heel, and brings the whole machine into harmony at the moment that the spring is about to take place.

The admirable mechanical economy of the leg of the ostrich may be illustrated by the parallel case of the Cornish pumping engine. Let us suppose a 100-inch cylinder engine about to commence its downward stroke, and to lift the pump rods, weighing many tons, by means of a force of steam which commences at a maximum, and is gradually let off by expansion to a safe and manageable quantity. It has been found by experience that it is necessary to cause a minute vibration of the beam before letting on the full force of the steam—such vibration shaking all the nuts and pins into their proper positions before the great and sudden action of all the parts takes place; and if such a precaution were to be omitted, it is well known that the sudden impulse of the steam would break the engine.

In the leg of the ostrich, the *M. rectus femoris* supplies the place of the preliminary vibration; it acts before the extensor muscles come into full play; it binds down the two patellæ, braces up the heel joint, and gives the signal for the *M. gastrocnemido-solæus* and other associated muscles to contract, and thus produces what may be regarded as one of the most striking phenomena in nature, viz., that the delicate bones and ligaments of a bird's leg, acted on by muscles equal to those influencing the hind leg of a horse, shall remain uninjured under the sudden action of forces, the slightest error in the application of which would break to pieces the machine on which they act.

I can admire, though I do not envy, the reasoning powers of those Naturalists who believe that a mechanism such as this grew out of pre-existing forms without the interposition of an intelligent mind; and for myself I must declare, that I could as easily believe that the modern Cornish engine had developed itself from its clumsy predecessors by the way of Natural Law, and without the interposition of intelligent engineers, as that the leg of the Ostrich was produced by Natural Selection from the commonplace legs of its less perfect ancestors.